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26JUL99 E464604-1 D02776
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1. Your reference — IPD/P2765

2. Patent application number *(The Patent Office will fill in this part)* — 26 JUL 1999 — **9917404.7**

3. Full name, address and postcode of the or of each applicant *(underline all surnames)* —
THE SECRETARY OF STATE FOR DEFENCE
Defence Evaluation and Research Agency
Ively Road, Farnborough
Hampshire GU14 6TD, UK

Patents ADP number *(if you know it)* — 54510007

If the applicant is a corporate body, give the country/state of its incorporation — GB

4. Title of the invention — Hydrogen Peroxide Based Propulsion System

5. Name of your agent *(if you have one)* — Bowdery Anthony Oliver

"Address for service" in the United Kingdom to which all correspondence should be sent *(including the postcode)* —
Defence Evaluation & Research Agency
IPD (DERA) Formalities
A4 Bldg
Ively Road
Farnborough
Hants GU14 0LX
United Kingdom

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6. If you are declaring priority from one or more earlier patent applications, give the country and the date of filing of the or of each of these earlier applications and *(if you know it)* the or each application number

Country	Piority application number *(if you know it)*	Date of filing *(day / month / year)*

7. If this application is divided or otherwise derived from an earlier UK application, give the number and the filing date of the earlier application

Number or earlier application	Date of filing *(day / month / year)*

8. Is a statement of inventorship and of right to grant of a patent required in support of this request? *(Answer 'Yes' if:*
a) any applicant named in part 3 is not an inventor, or
b) there is an inventor who is not named as an applicant, or
c) any named applicant is a corporate body.
See note (d))

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Continuation sheets of this form

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Claim*(s)* 1

Abstract 1

Drawing*(s)* 2

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Priority documents 0

Translations of priority documents 0

Statement of inventorship and right to grant of a patent *(Patents Form 7/77)* 1

Request for preliminary examination and search *(Patents Form 9/77)* 1

Request for substantive examination *(Patents Form 10/77)* 0

Any other documents *(please specify)* 0

11. I / We request the grant of a patent on the basis of this application.

Signature A O Bowdery Date

12. Name and daytime telephone number of person to contact in the United Kingdom Mrs Linda Bruckshaw 01252 392722

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Hydrogen Peroxide Based Propulsion System

The invention relates to hydrogen peroxide (H_2O_2) engines and in particular to a novel hybrid rocket/turbine hydrogen peroxide based engine and hydrogen peroxide based propulsion system for micro air vehicle propulsion.

Micro air vehicles (MAVs) play a key role in military and surveillance operations. For these MAVs, a range of engine characteristics is needed to meet specific requirements, such as low speed, low noise, high speed, etc. Features such as weight, ease of starting, reliability, etc. are important in the choice of the power plant. Air breathing engines or motors are usually attractive on weight grounds because they do not have to carry their own oxidant. However this may not be so important at small scales when the mass of the engine itself is relatively high. In addition, of course, small engines have relatively poor thermal and propulsive efficiency due to low cycle temperatures.

Hydrogen peroxide engines are known. The inventors have determined that these engines can be built small enough and give adequate performance requirements for use in MAV's. Hydrogen Peroxide can nowadays be generated 'in the field' by electrolytic techniques. It can be decomposed catalytically to produce steam and oxygen at high temperature and is an acceptable propellant in its own right with a high specific thrust and a low infrared (IR) signature.

The invention comprises a micro air vehicle comprising a tank adapted to contain hydrogen peroxide and connected to a region adapted to decompose hydrogen peroxide, and a nozzle adapted to exit the decomposition products of hydrogen peroxide to provide thrust.

Preferably a hydrocarbon fuel is provided to consume oxygen from the decomposition of hydrogen peroxide. Preferably pressurised oxygen is used to pressurise said fuel.

Further is provided a method of propelling a micro air vehicle comprising decomposing hydrogen peroxide and exiting the decomposition products through a nozzle to provide thrust

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The invention also comprises an engine comprising a tank adapted to contain hydrogen peroxide, a decomposition region/chamber suitable for decomposing hydrogen peroxide, a nozzle to accelerate the resulting decomposition products, and a turbofan located downstream of the exit of said nozzle and located within a duct so as to provide propulsive thrust.

Preferably a hydrocarbon fuel is provided to consume oxygen from the decomposition of hydrogen peroxide. Preferably pressurised oxygen is used to pressurise said fuel.

The invention will now be described with by way of example only and with reference to the following figures of which:

Figure 1 shows an embodiment of the invention comprising a fuel tank integral with a nozzle combustion chamber.

Figure 2 shows an embodiment of the invention comprising combustion chamber/nozzle and a ducted fan.

In a simple embodiment of the invention shown in figure 1, a MAV power plant 1 includes a fuel tank 2 containing 34g of H_2O_2. To hold this weight of fuel, the fuel tank can be a simple cylinder (2cm in diameter and 7.5cm in length). The fuel tank alone will weigh about 16g if it is made of aluminium and its thickness (1mm) should be sufficient to contain the pressure inside the tank. The fuel tank is connected to a combustion chamber/nozzle 3 of weight less than 2g.

The decomposition of H_2O_2 is an exothermic process in which a substantial rise in temperature occurs. Thermodynamic calculations on a 90% H_2O_2 solution show that a temperature of 1022K (749°C) and a pressure of 35.5bar (515psi) are achievable when the decomposition products are allowed to expand adiabatically to atmospheric pressure.

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A simple convergent/divergent nozzle is used in the flow parameter calculations necessary to diminish the combustion chamber pressure and nozzle exit area. A chamber pressure of 2.07bar (30psi) and a nozzle exit diameter of about 2mm will produce a mass flow through the nozzle of about 0.17g/s and an nozzle exit velocity of M 1.1. The thrust produced now is about 0.124N which is comparable to the amount required to propel an MAV. A monopropellant (H_2O_2) propulsion system has the advantages of low exhaust temperature and simple equipment design.

In a preferred embodiment, a bipropellant system uses hydrocarbon fuel to consume the excess oxygen. This system uses an additional tank to store the hydrocarbon. This has a clear advantage in endurance over the monopropellant system. However, the gain in endurance must weigh against the increase in combustion temperature and complexity in the fuel system. At temperatures in excess of 2400K, very few materials will be suitable for making the combustion chamber. Also, very efficient cooling techniques must be implemented to avoid damage to the combustion chamber. Preferably the propulsion system utilises hydrogen peroxide and kerosene as fuel and oxygen as the oxidant. A bipropellant (H_2O_2 and kerosene) propulsion system has a 70% improvement on flight endurance but has high exhaust temperature (circa 2700K) which makes the design and selection of material for the combustion chamber/nozzle very challenging. A bipropellant system with on-board oxygen gives the best flight endurance.

In the most preferred embodiment the system comprises a bipropellant system as described above with the addition of a ducted fan. Such an arrangement is not known per se. Figure 2 shows a figure showing the arrangement 4 of a hydrogen peroxide based ducted fan engine comprising a decomposition chamber/nozzle arrangement 5, and a turbofan 6 comprising turbine 7 and fan 8 arranged within a duct 9. In the ducted fan engine design, air passes through the outside of the combustion chamber/nozzle. The front of the combustion chamber has to be shaped to avoid flow separation. The combustion chamber/nozzle will attain very high temperatures during operation and the bypass flow will help to cool the nozzle. For a bypass ratio of 10, the duct exit flow velocity is found to be about 300m/s and the duct exit is 3mm in diameter. The fan rotational speed is estimated to be 1.63E6rpm. This is due to the small size of the fan. While these calculations are based on a nozzle throat

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area of 1mm diameter. The total thrust produced by this engine is 0.634N. Preferably a hydrocarbon based fuel is also burnt, at least in part using oxygen produced by the decomposition of hydrogen peroxide. The hydrocarbon may be burnt in the region of the nozzle.

Considerations have been given to the utilisation of an on-board oxygen cylinder as a pressure source for fuel delivery of oxygen (2.4g at 137.93bar) will increase the flight endurance by 2.7 minutes (0.38mm throat) storage tank of radius 1cm and length 3cm.

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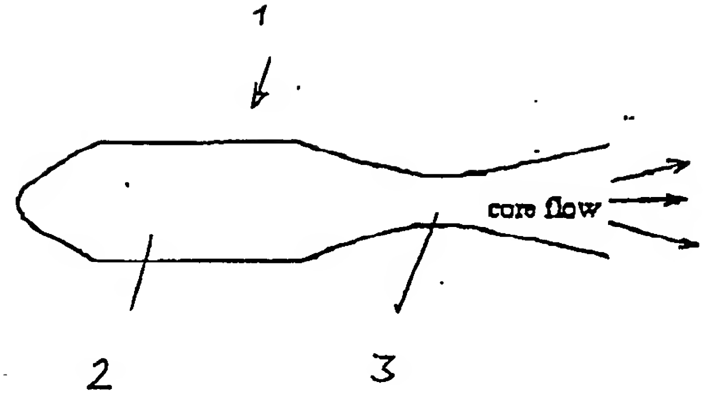
Claims

1. A micro air vehicle comprising fuel tank connected to a region adapted to decompose hydrogen peroxide, and a nozzle adapted to exit the decomposition products of hydrogen peroxide to provide thrust.
2. A micro air vehicle as claimed in claim 1 including means to provide a hydrocarbon fuel adapted to burn by consuming oxygen from the decomposition of hydrogen peroxide.
3. A micro air vehicle as claimed in claims 2 including pressurised oxygen to pressurise said fuel.
4. An engine comprising connection means to a tank adapted to contain hydrogen peroxide, a decomposition region/chamber suitable for decomposing hydrogen peroxide, a nozzle to accelerate the resulting decomposition products, and a turbofan located downstream of the exit of said nozzle, and located within a duct so as to provide propulsive thrust.
5. An engine as claimed in claim 4 additionally comprising a means for providing hydrocarbon fuel to said decomposition region/chamber or nozzle to be oxidised at least in part by the oxygen produced by the decomposition.
6. A micro air vehicle comprising an engine as claimed in claims 4 or 5.
7. A method of propelling a micro air vehicle comprising decomposing hydrogen peroxide and exiting the decomposition products through a nozzle to provide thrust.
8. A method as claimed in claim 7 including burning a hydrocarbon fuel with the oxygen produced from said combustion.
9. A method as claimed in claim 8 wherein said hydrocarbon is pressurised.
10. A method of propulsion comprising decomposing hydrogen peroxide and exiting the resulting said decomposition products through a nozzle towards a turbofan located with a duct.
11. A method as claimed in claim 10 wherein additionally comprising burning a hydrocarbon fuel with oxygen provided from decomposition.
12. A method of propelling a micro air vehicle as claimed in claims 10 or 11.

Abstract

A micro air vehicle comprising fuel tank connected to a region adapted to decompose hydrogen peroxide, and a nozzle adapted to exit the decomposition products of hydrogen peroxide to provide thrust. Preferably provide a hydrocarbon fuel is used to consume oxygen from the decomposition of hydrogen peroxide. Also an engine comprising a tank adapted to contain hydrogen peroxide. a decomposition region/chamber suitable for decomposing hydrogen peroxide, a nozzle to accelerate the resulting decomposition products, and a turbofan located downstream of the exit of said nozzle, and located within a duct so as to provide propulsive thrust.

Fig 1



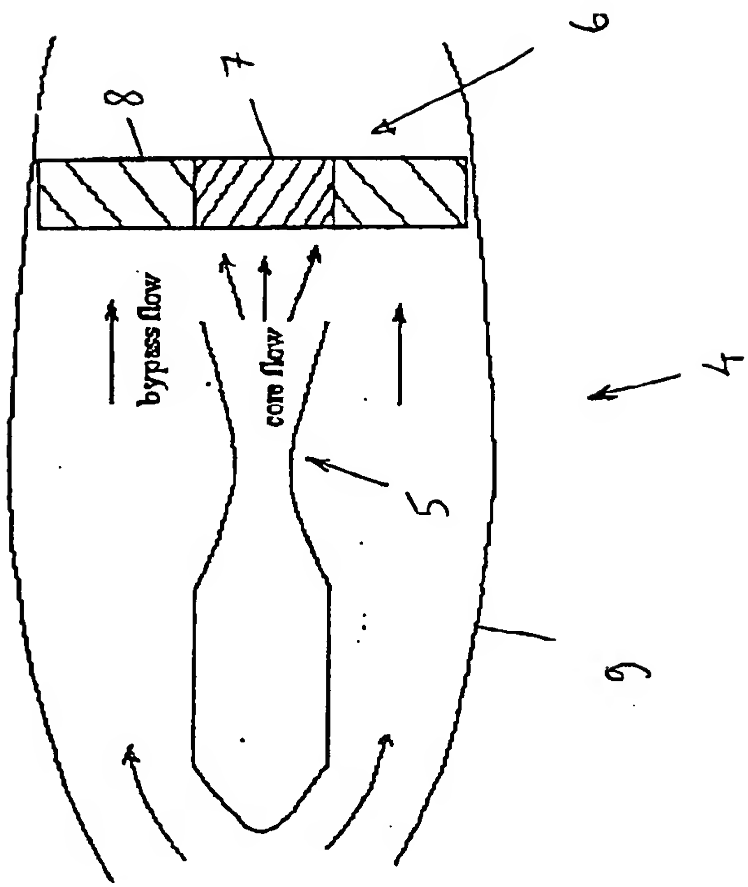


Fig 2